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PATENT SPECIFICATION

DRAWINGS ATTACHED

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Inventor: DAVID FULTON DAVIDSON.

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COMPLETE SPECIFICATION

Improvements in or relating to the cooling of large electrical generators

We, ASSOCIATED ELECTRICAL INDUSTRIES LIMITED, a British Company having its registered office at 1 Stanhope Gate, London W.1. (formerly at 33 Grosvenor Place, London, S.W.1.), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to improvements in the cooling of large electrical generators, such as the large generators which are used in central power stations.

Although it is now common practice to cool the stator windings of a large turbine-driven generator (e.g. a generator having an electrical output of 200 megawatts or more) with oil or with demineralised water, which is in direct contact with the conductors of the stator windings, and to use hydrogen at a pressure of several atmospheres and circulated by fans to cool the rotor windings and the stator core, there are practical difficulties in the design of such a cooling system

An object of the present invention is the provision of a large electrical generator having improved cooling.

According to the present invention, in a large electrical generator having a rotor and a stator enclosed in a gas tight casing, the rotor being provided with axial gas ducts communicating with radial ducts which extend outwardly to the annular gap between the rotor and the stator, the stator core being formed with ducts which extend outwardly through the core from that annular gap, and the rotor carrying fan means which in use circulate cooling hydrogen gas contained within the gas tight casing in a series flow through the ducts in the rotor and in the stator core, the end parts of the stator core, which are liable to larger stray load losses than the remainder of the stator core, are provided with radial ducts so arranged as to receive a smaller proportion of the discharge from the fan means direct from the fan means, the remaining larger proportion of the discharge passing first axially and then radially through the rotor to be discharged into the annular gap, to flow across the annular gap, outwardly through the ducts in the remainder of the stator core and, after cooling, to return to the inlet or inlets of the fan means, and seals are provided between the rotor and the stator to preclude intermingling of the smaller proportion of the discharge in its passage from the fan means to the respective stator ducts with the remaining proportion of the discharge in its passage from the rotor to the stator across said annular gap.

The invention will now be described, by way of example, with reference to the accompanying diagrammatic drawing, which is a sectional side elevation through a large electrical generator.

The generator includes a rotor 1 arranged with its axis horizontal and supported at its ends on parts of reduced diameter by bearings 3. This rotor is formed with axially extending ducts 5 communicating with radially extending ducts 7 distributed over the central part 1A of the length of the rotor and ducts 5 terminate at the axially facing ends of the part 1A. Thus continuous passages for the flow of cooling hydrogen extend axially along (through the ducts 5) and then radially outwards (through the ducts 7) of the rotor part 1A, in which rotor part the rotor windings are carried and to which part the heat generated ohmically in the rotor windings is transferred. The rotor extends through a laminated metal core 15 of the generator stator, and the laminations, the planes of which extend transversely of

the rotor axis, are axially grouped into packets so as to leave between adjacent packets radially extending ducts 17. Thus hydrogen discharged radially from part 1A of the rotor 1 flows radially outwardly through the ducts 17 and extracts heat from the stator core. Gas seals 18 preclude the axial flow of hydrogen to and from the annular gap between the periphery of the rotor and the inner surface of the stator core 15.

The rotor 1 and the stator core 15 are enclosed in a stator casing 19 which is cylindrical in form and is gas-tight, the rotor extending through gas-tight seals 21 on the casing end walls 19E at locations inwardly of the bearings 3. At each end of the rotor a high pressure (e.g. 100 inches water gauge when running in air) centrifugal fan 23 is mounted on the part of the rotor of reduced diameter, inside the casing 19, and each of these fans is surrounded by a shroud 25 continued outwardly so as to define a gas flow passage 27 extending from the outside of the stator core 15 to the fan inlet. Each fan 23 serves, therefor, when the rotor is running at its normal operating speed of 3,000 r.p.m., to force hydrogen gas round a closed circuit extending from the fan outlet through the rotor ducts 5 and 7 and the stator ducts 17 and passages 27 to the fan inlet. Disposed in the passages 27 are water-cooled indirect heat exchangers 29 which serve to extract heat from the circulating hydrogen. These heat exchangers are provided with a constant throughflow of cooling water so that the heat generated in the rotor and in the stator is extracted via the hydrogen, the heat exchangers 29 and the cooling water to a heat drain outside the casing 19. The stator conductors are hollow and are cooled by the throughflow of demineralised water flowing through inlet/outlet headers 31 disposed inside the casing 19.

It will be seen that in use of the electrical generator a simple radial flow of cooling hydrogen gas takes place in the stator core. At the same time, the gas flow through the rotor, the operating temperature of which presents a main limiting feature in the design of such a large electrical generator, is created by the action of the fans 23 augmented by the fan effect of the radial ducts 7 in the rotating rotor 1 in series in the hydrogen circuit. A small amount of the gas discharged by each fan 23 is separately directed through radial ducts 33 in each end part of the stator core 15 to provide increased local cooling of these parts of the core, ducts 33 discharging into the passage 27.

The end regions of the stator core, where the stray load losses are high, are thus cooled by a flow of cold hydrogen directly from the fans 23, and hot spots in these regions of high loss are thereby avoided. The gas flow required for this purpose is less than 10% of the total gas flow.

As an alternative to the use of centrifugal fans 23, multi-stage axial fans can be used.

WHAT WE CLAIM IS:—

1. A large electrical generator having a rotor and a stator enclosed in a gas tight casing, the rotor being provided with axial gas ducts communicating with radial ducts which extend outwardly to the annular gap between the rotor and the stator, the stator core being formed with ducts which extend outwardly through the core from that annular gap, and the rotor carrying fan means which in use circulate cooling hydrogen gas contained within the gas tight casing in a series flow through the ducts in the rotor and in the stator core, wherein the end parts of the stator core, which are liable to larger stray load losses than the remainder of the stator core, are provided with radial ducts so arranged as to receive a smaller proportion of the discharge from the fan means direct from the fan means, the remaining larger proportion of the discharge passing first axially and then radially through the rotor to be discharged into the annular gap, to flow across the annular gap, outwardly through the ducts in the remainder of the stator core and, after cooling, to return to the inlet or inlets of the fan means, and seals are provided between the rotor and the stator to preclude intermingling of the smaller proportion of the discharge in its passage from the fan means to the respective stator ducts with the remaining proportion of the discharge in its passage from the rotor to the stator across said annular gap.

2. An electrical generator as claimed in Claim 1, wherein the fan means consist of a first fan disposed towards one end of the rotor and a second fan disposed towards the other end of the rotor, and the two fans direct the cooling hydrogen gas both into the axial ducts of the rotor respectively from the two opposite ends of the rotor and into the radial ducts provided in each end part of the stator core.

3. An electrical generator as claimed in Claim 1 or Claim 2, wherein the fan means are high pressure centrifugal fans.

4. An electrical generator as claimed in Claim 1 or Claim 2, wherein the fan means are multi-stage axial flow fans.

5. An electrical generator as claimed in Claim 3, wherein the fans are such that if running in air they would develop a pressure increase of about 100 inches of water gauge.

6. An electrical generator as claimed in Claim 1, wherein the smaller proportion of the fan means discharge is less than 10 per cent of the total discharge.

7. An electrical generator as claimed in any preceding Claim, wherein water-cooled indirect heat exchangers are provided inside the gas tight casing and radially outwards of the stator, and these heat exchangers are arranged to effect the specified cooling of the hydrogen gas returning to the inlet or inlets of the fan means.

8. An electrical generator as claimed in any preceding Claim, wherein the stator core is laminated the planes of the laminations extending transversely to the rotor axis, and these laminations are arranged in packets which are spaced apart, and the spaces between the packets of laminations provide the ducts in the stator core.

9. A large electrical generator provided with a rotor and a stator and means for cooling these substantially as shown in, and arranged to operate substantially as hereinbefore described with reference to, the accompanying drawing.

J. W. RIDDING,
Chartered Patent Agent,
33, Grosvenor Place,
London, S.W.1.,
Agent for the Applicants.

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1 SHEET
This drawing is a reproduction of the Original on a reduced scale.